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SENT VIA ELECTRONIC MAIL

June 5, 2012

State Water Resources Control Board
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Mark Gowdy - mgowdy@waterboards.ca.gov
Caren Trgovcich - ctrgovcich@waterboards.ca.gov
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Re: Hydrology Study for New Melones

Dear State Water Board Staff:

As we discussed at our meetings in May, New Melones presents some unique challenges when modeling the hydrology of the Stanislaus River Basin and New Melones operations.

In our discussions when we were comparing modeled storage, one of the first points made by Mr. Grober was, and we are paraphrasing here, "there really isn't much difference between the studies except for the starting point reservoir storage in 1922." We pointed out that even the starting point in 1922 is subjective, given the Biological Opinion's Table 2E and the State Water Board's proposed unimpaired flow regime of 20-60 percent. Assumptions for CVP deliveries also weigh heavily on the assumption of starting point storage.

Attached is Dan Steiner's memo and analysis of the appropriate starting point for 1922. Many previous studies for the Stanislaus River have assumed 1,700,000 acre-feet. Based on Mr. Steiner's analysis, the "new" starting point could range between 700,000-1,200,000, depending upon the assumptions of how New Melones Reservoir would be operated prior to 1922. This means the development of viable operating rules and need of "add water" is not only challenging during the

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1987-1992 drought, but it is also applicable to the initial period of the hydrology 1922-1934. The higher percentage of required minimum flows, the lower the starting point in 1922.

Very truly yours,

O'LAUGHLIN & PARIS LLP

TIM O'LAUGHLIN

TO/tb
Attachment
cc: San Joaquin Tributaries Authority
Thomas Howard, Executive Director
Charlie Hoppin, State Water Board Chairman
Frances Spivy-Weber, State Water Board Vice-Chair
Tam Doduc, State Water Board Member
Steven Moore, State Water Board Member

Memorandum

Subject: **Beginning Storage for Stanislaus River Operations Studies**
From: **Daniel B. Steiner**
Date: **May 29, 2012**

1. Introduction

The operation of the Stanislaus River has been depicted using various simulation models, most recently by such models as CalSim II and the spreadsheet model developed by the Districts. These models simulate monthly-sequential operations from the beginning of a hydrologic period such as October 1921 (WY 1922) through at least September 2003 (WY 2003). An important result of these simulations is the depiction of system operations and project parameters (e.g., reservoir storage, water deliveries and releases) during a long-term simulation of historical hydrologic conditions that incorporate extremes of flood and multi-year droughts. Although historical sequences of hydrology may never exactly replicate themselves in the future, the assumption of the recurrence of historical hydrology is typically used to illustrate what may occur in the future.

For the Stanislaus River Basin, the combination of its physical water project features such as New Melones Reservoir (approximately full at 2,420,000 acre-feet), its unimpaired runoff (an average of 1,120,000 acre-feet, with a minimum computed runoff of 155,000 acre-feet) and the structure of its water demands create a challenge in developing a systematic operating rule that performs viably across all hydrologic conditions. The management and use of reservoir storage is critical to maintaining releases during drought sequences.

Studies performed in the past have focused heavily on “rules” that provide an operation during the 1987-1992 drought sequence, which has appeared in the past to be the worse period to operate through. Water year 1986 was historically a water-abundant year leading to essentially full carry-over conditions entering the first year of the 6-year drought. Operation rules would be developed to guide operations through the 6-year drought resulting in minimum reservoir storage occurring during the end of 1992. Water year 1993 was usually wet enough to fully recover the system from the 6-year drought. Although there are other multi-year drought sequences throughout the 1922-2003 period, these sequences did not draw the system to minimum storage whereby the “rules” would require refinement beyond what was necessary to provide operations during the 1987-1992 drought. Review of study results would illustrate New Melones Reservoir storage fluctuating up and down during the sequence of years with the greatest draw from storage occurring during the 1987-1992 sequence.

Critical to the depiction of reservoir storage during the early years of the simulation is the assumption for reservoir storage at the beginning of the study, the storage assumed for the end of September 1921. Historically, this value has been assumed to be near-normal, about 1,700,000 acre-feet or more. This validity of this assumption is becoming more and more important as alternative flow requirements and water demands have been identified for the Stanislaus River. The question being, given the hydrology immediately prior to 1922, is this an appropriate assumption of storage beginning Water Year 1922? The assumption will potentially affect the amount of water that is available during a critical drought period.

The ability to provide a viable “one-rule-fits-all” hydrology has been made difficult, if not made at least impracticable. Discussion has been occurring to consider an alternative planning approach for Stanislaus River operations. The approach is considering the recognition that the 1987-1992 drought has a very small likelihood of recurrence, and operations could be based on lesser drought events. This potential outcome makes it important to critically assess the assumption for “beginning storage” for Stanislaus River studies, as the initial hydrologic sequence of the 1920s and 1930s may become the most severe period used for operations planning.

The purpose of this memorandum is to provide a brief description of an analysis concerning the estimation of the beginning storage parameter (end of September 1921) used in future studies.

2. Analysis Approach and Pre-1922 Hydrology

Since the models perform sequential operations from one month to the next, with reservoir storage at the end of September 1921 dependent upon operations that occur prior to that period, it is appropriate to extend hydrology and operations backward to a point in time (prior to September 1921) when ending storage in the reservoir is no longer affected by a previous month's operations (i.e., find the last period of reservoir spill). Therefore, the unimpaired hydrology was extended backward coincident with the length of an available record (1909). This record was then "impaired" using assumptions for upstream operations, which provided a monthly time series of projected inflow to New Melones Reservoir. The Districts' spreadsheet model was then used to simulate system operations for the 1909 through 1921 period to identify periods of controlled reservoir operations and a projection of storage for September 1921. The sensitivity of the reservoir control periods and projected September storage was tested by modifying assumptions for system controlling criteria such as required minimum instream flows.

DWR computes and publishes records of unimpaired flow for the Stanislaus River Basin and other watersheds of California. Estimates for the basin's unimpaired flow are described in "California Central Valley Unimpaired Flow Data, Fourth Edition", November 2006, for the Water Year 1921 through Water Year 2003 period. Some of these data have been extended by me or others through the current year. A more lengthy partial record of unimpaired runoff within the basin was found in DWR's estimate of the San Joaquin River Basin index (60-20-20) (http://cdec.water.ca.gov/cgi-progs/iodir/WSIHIST) which provided estimates for October-March and April-July unimpaired runoff for the period 1909-1921. Needing a estimate of August-September runoff for the 1909-1921 period, a relationship between October-July runoff and August-September runoff was developed using data from a period that included available records (1922-2010). The monthly distribution of unimpaired runoff in the basin was then developed by distributing each year's period-volumes in the same proportional pattern that occurred for the Tuolumne River (the monthly record of unimpaired flow in the Tuolumne River Basin for the period 1909-1921 was available).

The unimpaired flow record was then used to develop a projection of impaired runoff into New Melones Reservoir which was cognizant of upstream regulation by New Spicer Meadows, Donnells and Beardsley Reserevoirs. A generalized operation of these facilities was established from review of recent operations, and a month-to-month simulation of upstream operations was developed to provide an estimate of New Melones Reservoir inflow for 1909-1921. Table 1 illustrates the estimated unimpaired runoff, upstream operation and impaired runoff to New Melones Reservoir used in the 1909-1921 analysis.

The Districts' spreadsheet model was modified to incorporate the 1909-1921 inflow data, and was executed for several regulatory and operational scenarios. Several simplifying assumptions were made to quickly reach initial conclusions concerning pre-1921 operations.

- 1909-1921 inflow data for New Melones Reservoir is the sole, underlying hydrologic parameter changed in the model. The new inflow data was swapped with the record that represented 1922-1934. Minor hydrology such as projected side-flow to Tullock Reservoir and accretions below Goodwin Dam were not changed from the 1922-1934 series.
- The projected annual varying OID/SSJID land use water requirements for the 1922-1934 were used to depict the requirements for 1909-1921. Although the year-to-year projected requirements for 1909-1921 are not likely to be coincident with those projected for the 1922-1934 period, the average for the period (about 534 TAF/year) approximated the long term average use.
- The calculation of OID/SSJID "formula" water depicts the projection of 1909-1921 inflow. The full "600 TAF" was available for use each year, but may have been partially unused due to land use assumptions.
- D1641 water quality and flow requirements which may require New Melones Reservoir releases were "turned off" due to the absence of a San Joaquin River depiction for 1909-1921. This aspect requires recognition within the results.

Table 1
Unimpaired Runoff and Upstream Operation – 1909-1921

Stanislaus River UF based on Tuolumne River UF Distribution (TAF)

WY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total	Apr-Jul
1909	14	13	19	348	237	154	221	337	419	137	42	14	1,956	1,114
1910	12	110	172	143	78	176	257	286	122	32	13	17	1,419	697
1911	12	15	29	270	160	325	295	347	550	304	69	17	2,393	1,497
1912	7	6	10	20	20	43	55	181	209	36	6	3	594	480
1913	2	18	9	15	20	37	94	212	131	39	5	4	587	475
1914	3	10	12	315	148	178	200	362	346	165	39	9	1,786	1,073
1915	4	4	5	37	131	118	190	295	361	130	21	5	1,300	976
1916	4	3	8	163	135	296	273	312	321	124	30	12	1,680	1,030
1917	40	20	38	30	126	79	179	279	435	127	21	7	1,383	1,021
1918	3	4	7	8	34	166	153	190	227	23	5	8	827	593
1919	27	18	17	11	40	61	159	333	85	15	7	4	777	592
1920	3	2	14	14	17	94	127	263	173	27	7	4	746	589
1921	25	33	43	121	96	143	160	279	290	60	10	5	1,264	790

Simulated New Melones Inflow after Impairement (TAF)

WY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total	Apr-Jul
1909	44	43	49	280	237	154	199	257	399	137	79	79	1,956	1,114
1910	42	100	172	143	60	176	257	253	53	54	54	54	1,418	697
1911	42	45	59	180	180	300	295	300	503	304	93	92	2,393	1,497
1912	45	45	45	45	45	45	50	75	59	50	50	50	604	480
1913	45	45	45	45	45	45	50	75	60	60	50	50	615	475
1914	45	45	45	250	100	150	200	300	300	165	74	74	1,748	1,073
1915	45	45	45	45	100	100	100	250	313	131	63	62	1,299	976
1916	45	45	45	150	100	250	250	250	279	124	71	71	1,680	1,030
1917	70	50	60	60	100	100	150	200	337	127	65	64	1,383	1,021
1918	45	45	45	45	45	100	120	120	126	60	50	50	851	593
1919	45	45	45	45	45	60	120	150	71	60	51	50	787	592
1920	45	45	45	30	30	60	80	150	88	60	55	55	743	589
1921	45	45	70	120	100	100	140	200	237	60	60	55	1,232	790

Simulated Upstream Storage (TAF)

WY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1909	220	190	160	227	227	228	249	329	349	350	314	250
1910	219	230	229	230	248	248	248	281	350	328	287	250
1911	220	190	160	250	229	255	255	302	350	350	326	250
1912	212	173	138	113	87	85	90	196	345	331	287	240
1913	198	171	135	105	80	72	116	253	324	303	258	212
1914	170	135	101	166	214	242	242	304	350	350	315	250
1915	208	167	127	118	150	168	257	302	350	350	307	250
1916	209	166	129	142	177	223	246	308	350	350	309	250
1917	220	190	168	138	164	143	173	252	350	350	307	250
1918	208	166	128	91	80	146	179	249	350	313	268	225
1919	207	180	152	117	112	113	152	335	350	304	261	215
1920	173	131	100	85	72	106	152	265	350	317	269	218
1921	198	186	158	159	155	198	218	297	350	350	300	250

3. Scenario Results

Several operation scenarios were tested which led to different results. The first scenario tested assumed the SJTA depiction of the SWRCB Staff's "30% Unimpaired Flow" requirement. The primary operation criteria of this scenario include:

- Goodwin minimum flow requirements equal to the greater of 30% of Stanislaus River unimpaired runoff (with bounds) or 2009 BO Table 2E flows for February through June, and Table 2E flows for the remainder of the year.
- Release for full DO compliance.
- CVP Allocations: 10 TAF when NMI < 1,400; 155 TAF when NMI > 2,178; otherwise 59 TAF.
- Remove monthly Goodwin release limitation.
- Beginning storage WY 1909, 1,700 TAF.

Results of this scenario are shown in Table 2.

Table 2
New Melones Simulation 1909-1921 – SWRCB 30% or RPA

	New Melones		Goodwin								
	New Melones Inflow	New Melones Storage	OID & SSJID Canals	SEWD NM Water	CSJWCD NM Water	Instream Fish	Dissolved Oxygen	Total Goodwin Release to River	Release above Minimum	NM Forecast Index	Districts Formula Water
Avg	1285		534	55	70	507	4	609			
	WY	EOS	WY	M-F	M-F	M-F	M-F	M-F	M-F		WY
1909	1956	2000	506	75	80	653	0	1150	496	3273	600
1910	1418	1738	507	75	80	614	0	673	59	2871	600
1911	2393	2000	600	75	80	675	0	1322	648	3857	600
1912	604	1436	444	75	80	388	3	391	0	2349	600
1913	615	1069	559	10	49	318	12	330	0	1891	600
1914	1748	1570	515	75	80	565	0	565	0	2675	600
1915	1299	1613	509	75	80	550	0	550	0	2720	600
1916	1680	1929	530	75	80	635	0	711	76	3111	600
1917	1383	1794	559	75	80	652	0	652	0	3013	600
1918	851	1370	549	75	80	474	0	474	0	2461	600
1919	787	1181	531	10	49	323	12	335	0	2025	600
1920	743	898	574	10	49	350	12	362	0	1767	600
1921	1232	1040	564	10	49	395	12	407	0	1972	600

The results show that New Melones Reservoir released in excess of minimum requirements during 1909, 1910, 1911 and then again in 1916. As evidenced by the large annual inflows during 1909-1911 (average annual runoff is approximately 1,120,000 acre-feet), these years had extraordinary runoff which eventually leads to releases in excess of minimum requirements. Individually, 1909 and 1911 were sufficiently wet that by the end of the year (end of September), carryover storage was at its modeled maximum value (2,000,000 acre-feet). WY 1910, a slightly less robust year illustrates that even with better-than-average inflow New Melones Reservoir storage (1,738,000 acre-feet) at the end of the water year may be less than maximum even when there are excess releases during the year. In combination, the years incorporate a sequence of hydrology that would provide a carryover condition at New Melones Reservoir at or near full allowable storage.

The 1912-1915 series of year incorporates a mixture of dry and wetter years, and illustrates the variability of New Melones Reservoir carryover storage. In each year carryover storage varies and is a function of several factors other than just inflow. The instream flow requirements and CVP delivery allocations are based on a mixture of parameters including inflow, unimpaired runoff and reservoir storage. Carryover storage will typically not be directly related to reservoir inflow. As seen in the results, the sequential

wetness of WY 1914-1916 did slowly recover system storage, and in WY 1916 excess releases occurred and carryover storage in September (1,929,000 acre-feet) was near the maximum allowable value.

Subsequent to WY 1916, the years varied in wetness, without any "fill" occurrences. The results of this scenario indicate that carryover storage for September 1921 is 1,040,000 acre-feet.

A second scenario evaluated an alternative system operation that changed only the minimum instream flow requirement. In this case the SJTA depiction of the SWRCB Staff's "40% Unimpaired Flow" requirement replaced the previous requirement. Results of this scenario are shown in Table 3.

Table 3
New Melones Simulation 1909-1921 – SWRCB 40% or RPA

	New Melones		Goodwin								
	New Melones Inflow	New Melones Storage	OID & SSJID Canals	SEWD NM Water	CSJWCD NM Water	Instream Fish	Dissolved Oxygen	Total Goodwin Release to River	Release above Minimum	NM Forecast Index	Districts Formula Water
Avg	1285		534	55	70	556	6	641			
	WY	EOS	WY	M-F	M-F	M-F	M-F	M-F	M-F		WY
1909	1956	2000	506	75	80	715	0	1150	435	3273	600
1910	1418	1719	507	75	80	650	0	674	24	2871	600
1911	2393	2000	600	75	80	754	0	1323	569	3857	600
1912	604	1406	444	75	80	418	3	421	0	2349	600
1913	615	1001	559	10	49	373	12	386	0	1861	600
1914	1748	1418	515	75	80	649	0	649	0	2592	600
1915	1299	1388	509	75	80	629	0	629	0	2556	600
1916	1680	1611	530	75	80	733	0	733	0	2874	600
1917	1383	1581	559	75	80	587	0	587	0	2760	600
1918	851	1183	549	75	80	480	3	483	0	2278	600
1919	787	941	531	10	49	381	12	393	0	1837	600
1920	743	612	574	10	49	401	21	422	0	1529	600
1921	1232	677	564	10	49	463	21	484	0	1681	600

Results again show that the first three years of operation still produce excess releases and a maximum allowable carryover storage going into WY 1912. However, with the slight change in downstream flow requirements excess conditions do not occur subsequently, which means that the carryover storage indicated for September 1921 (677,000 acre-feet) is now dependent upon water allocation rules for the entire period of 1912 through 1921.

A third scenario was tested that assumed the SJTA depiction of the SWRCB Staff's "60% Unimpaired Flow" requirement. As a conclusion of earlier SJTA studies, in this scenario the SJTA assumption for CVP deliveries was changed to only allow deliver in years when such a deliver would not affect carryover storage. The results of this scenario are shown in Table 4.

Table 4
New Melones Simulation 1909-1921 – SWRCB 60% or RPA

	New Melones		Goodwin								
	New Melones Inflow	New Melones Storage	OID & SSJID Canals	SEWD NM Water	CSJWCD NM Water	Instream Fish	Dissolved Oxygen	Total Goodwin Release to River	Release above Minimum	NM Forecast Index	Districts Formula Water
Avg	1285		534	12	12	663	5	742			
	WY	EOS	WY	M-F	M-F	M-F	M-F	M-F	M-F		WY
1909	1956	2000	506	75	80	771	0	1151	380	3273	600
1910	1418	1774	507	0	0	762	0	828	66	2871	600
1911	2393	2000	600	75	80	810	0	1323	513	3857	600
1912	604	1467	444	0	0	493	3	496	0	2349	600
1913	615	1041	559	0	0	488	12	500	0	1940	600
1914	1748	1501	515	0	0	750	0	750	0	2615	600
1915	1299	1531	509	0	0	723	0	723	0	2631	600
1916	1680	1772	530	0	0	865	0	865	0	3008	600
1917	1383	1753	559	0	0	732	0	732	0	2914	600
1918	851	1361	549	0	0	608	0	608	0	2439	600
1919	787	1091	531	0	0	462	12	474	0	2025	600
1920	743	690	574	0	0	548	21	569	0	1690	600
1921	1232	660	564	0	0	612	12	624	0	1752	600

The results show the excess flow conditions of the first three years, even with very large flow requirements and large CVP deliveries. These results suggest that any further refinement of the analysis concerning 1921 carryover storage could be focused on the hydrology of 1912 through 1921. It appears reasonable to assume the carryover storage for September 1912 will be at maximum allowable.

The counter action of increased flow requirements and reduced CVP deliveries lead to a September 1921 carryover storage of 660,000 acre-feet, very similar to the previous result. The similarity of result for these last two scenarios does not suggest a plateauing of effects. The result is merely a coincidence of numbers. One single change in annual CVP delivery would affect the resulting carryover storage by up to 155,000 acre-feet.

One last scenario was investigated. In this case a version of the Districts' proposed operation plan was assumed. The following assumptions were included.

- Goodwin minimum flow requirements equal to three steps: 174/235/318 TAF, or the SWRCB 20% UF requirement if larger.
- DO is assumed to have compliance with these release schedules.
- CVP Allocations: 10 TAF when NMI < 1,400; 155 TAF when NMI > 1,800; otherwise 59 TAF.
- Remove monthly Goodwin release limitation.

Due to not having a San Joaquin River operation for 1909-1921, releases from New Melones for D1641 flow and quality requirements were not enabled.

Results for this scenario are shown in Table 5.

Table 5
New Melones Simulation 1909-1921 – Districts' Operation Plan*

	New Melones		Goodwin								
	New Melones Inflow	New Melones Storage	OID & SSJID Canals	SEWD NM Water	CSJWCD NM Water	Instream Fish	Dissolved Oxygen	Total Goodwin Release to River	Release above Minimum	NM Forecast Index	Districts Formula Water
Avg	1285		534	75	80	363	0	567			
	WY	EOS	WY	M-F	M-F	M-F	M-F	M-F	M-F		WY
1909	1956	2000	506	75	80	410	0	1149	739	3273	600
1910	1418	1900	507	75	80	365	0	671	306	2871	600
1911	2393	2000	600	75	80	471	0	1322	851	3857	600
1912	604	1521	444	75	80	278	0	278	0	2349	600
1913	615	1102	559	75	80	288	0	288	0	2003	600
1914	1748	1749	515	75	80	412	0	412	0	2731	600
1915	1299	1939	509	75	80	397	0	595	199	2925	600
1916	1680	2000	530	75	80	424	0	862	437	3265	600
1917	1383	2000	559	75	80	394	0	514	119	3013	600
1918	851	1598	549	75	80	366	0	366	0	2596	600
1919	787	1364	531	75	80	278	0	278	0	2262	600
1920	743	1036	574	75	80	301	0	301	0	1961	600
1921	1232	1160	564	75	80	334	0	334	0	2126	600

The results shown that with the Districts' proposed plan excess releases would occur early in the sequence of years and during 1916-1917. Even with the full carryover condition of 1917, September 1921 carryover storage is projected to be 1,160,000 acre-feet.

4. Observations and Recommendations

As studies proceed concerning an operation plan for the Stanislaus River I recommend that a "more appropriate" beginning storage be used for September 1921. This recommendation could have a significant effect on the planning approach for drought management and rule development.

As previously described, there is current thought to discard the 1987-1992 drought sequence from the traditional drought planning sequence. This approach suggests developing "rules" for all other sequences and allowing the 1987-1992 period to be an "exception" during which special options will be considered. In past studies, typically the 1987-1992 hydrology required these special options and were highlighted as an "added water" sequence. Heretofore, the 1987-1992 drought was thought to be the only exception in hydrology. However, the analysis performed for this paper illustrates the significant overestimation of reservoir storage that has been assumed to be available at the beginning of model simulations of the 1920s and 1930s. This overestimation could amount to 500,000 acre-feet or more and viewed through the results of past studies may drive the 1922-1934 sequence to also require "added water".

My recommendation is to explicitly address September 1921 storage in each alternative study we perform. From what I have evaluated, that storage may vary between 700,000 and 1,200,000 depending upon the scenario. The storage we previously assumed was 1,700,000 acre-feet. The difference of 500,000-1,000,000 acre-feet in beginning storage mainifests as a reduced amount of water available during the initial modeling period beginning in WY 1922. Typically the low point within the initial sequence of years is during 1934 (13 years), with full recovery not occurring until 1941.

In my recent "District Proposal" study I had already needed to provide "added water" (100,000 acre-feet) to maintain 150,000 acre-feet of New Melones Reservoir storage during 1934. The dynamic nature of the water allocations will not require an additional 500,000-1,000,000 acre-feet of added water to make a comparable run. Instead, because the allocations are partially tied to storage (which will be related to the beginning storage assumption, both CVP and fish allocations will be reduced during the period from the

levels originally portrayed. My initial estimate is that an additional 100,000 acre-feet of added water on top of the original 100,000 acre-feet of added water will be needed to maintain New Melones Reservoir storage at 150,000 acre-feet in 1934.

However, this all suggests that we want to land at an approach for “special rules” for not only the worse drought (1987-1992) but also for the next worse sequence. Alternatively, the allocation rules could be changed (e.g., CVP contractors) that changes the full delivery volume (155 TAF) to trigger a little less often than at 1,800. The trigger would be adjusted to keep the study out of the “special” zone except for the 1987-1992 drought.